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(54) DEVICE FOR MONITORING OF CORROSION

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DEVICE FOR MONITORING OF CORROSION

BACKGROUND OF THE INVENTION

Field of the Invention:

The invention under consideration concerns a device for monitoring corrosion.

Description of the Invention:

The potentials which different metals take on in an electrolyte in comparison with a reference potential given by a reference electrode permit important corrosion-chemical statements. Metals or alloys which can form protective layers in concerned electrolytes show potentials which can vary in a given potential range. In these cases, conclusions can be drawn from the potential as to the electro-chemical condition of the metal. In particular, it can be deduced whether hole-forming corrosion is possible or not.

Particularly in the case of heat exchangers, especially for corrision-endangered condensers of large coolers in steam power plants with a high capacity, it would be of a high economical importance if the free corrosion potential could be monitored during operation. However, this is not possible with the known arrangements for the reasons discussed hereinbelow.

Normally, water chambers are not accessible during operation for potential measuring. Also, there are modern water chambers equipped with protective anodes for the cathodic corrosion protection whereby the penetration tubes take on a mixed potential which is different from the free corrosion potential. Finally, the free corrosion potential normally developes only in the inner part in case of long heat exchanger tubes (for example 10 m with today's types of condensers). Thus, this inner

part is decisive for the corrosive behavior of the heat exchanger tube. However, as can be noted from what has been said above, this point is practically inaccessible for a measuring probe.

It is now the task of the invention under consideration to provide a device for the monitoring of corrosion-endangered tubes, particularly for heat exchangers operating with water, which overcomes the aforementioned difficulties and which is also particularly suitable to measure the free corrosion potential of heat exchangers during operation.

SUMMARY OF THE INVENTION

The present invention pertains to an apparatus for the monitoring of corrosion in at least one metal heat exchanger tube through which a corroding medium flows with an electrical measuring instrument controlled by the condition of a surface in contact with the corroding medium, which surface comprises the material of at least one tube to be monitored.

In one aspect the apparatus includes at least one branch placed parallel to the flow in the tube to be monitored wherein the branch comprises a monitor tube connected via electrical insulating conduit means at its opposite ends to the heat exchanger tube to be monitored. The monitor tube has an inner cross-section which is at least equal to that of the tube to be monitored such that the corroding medium in the monitor tube flows with the same speed as in the tube to be monitored, the monitor tube comprising the same metallic material as the tube to be monitored. A reference electrode is disposed in electrical contact with the corroding medium in the branch and an electrical contact device is mounted on the monitor tube with the electrical measuring instrument being electrically connected with the reference electrode and with the contact device.

In another aspect the apparatus includes a branch placed parallel to the flow in the tube to be monitored wherein the branch comprises at least one monitor tube connected via electrical insulating conduit means at its opposite ends to the heat exchanger tube to be monitored, and the monitor tube having an inner cross-section which is at least equal to that of the tube to be monitored such that the corroding medium in the monitor tube flows with the same speed as in the tube to be monitored. The monitor tube comprises the same metallic material as the tube to be monitored and a pair of electrical contact devices are mounted on the monitor tube with the electrical measuring instrument being connected with the monitor tube so as to form a closed electrical circuit. In a still further aspect the apparatus may comprise at least two monitor tubes within an insulating line connecting the monitor tubes.

A branch is placed parallel to the flow in the heat exchanger tube to be monitored. The monitor tubes each comprise a portion of the branch and the branch has an inner cross-section which is at least equal to that of the tube to be monitored, the corroding medium in the monitor tubes flowing with the same speed as in the tube to be monitored. The monitor tubes comprise the same metallic material as the at least one tube to be monitored. An electrical contact device is connected to each of the monitor tubes, the electrical measuring instrument being electrically connected to form one electrical circuit with the monitor tubes through the contact devices, which electrical circuit is closed by the corroding medium.

Among the associated advantages accomplished with the present invention, there is, first of all, the already mentioned fact that, the free corrosion potential can be continuously monitored whereby critical operational conditions for localized corrosion can be immediately recognized. This represents a prerequisite in order to take remedial measures in time. Additionally, the respective system must not be turned off and opened up for the respective measuring.

Of further significance is the fact that, with a device according to the invention, the measured potential is the same as that in the interior even of a very long condenser and heat exchanger tubes which are not accessible for measuring. This is due to the fact that the surface of the test tube is exposed to the same media and to the same operational conditions as the tubes to be monitored. Furthermore, since the entire device according to the invention is not smaller at any point than the inner cross-section of the tubes to be monitored, the advantage is obtained that the sponge shots of a sponge shot cleaning system can also pass through it without any difficulty. Thus, the condition of the surface of the test tube is also representative with the temporary operation of a sponge shot cleaning system, and all operational conditions important for the recognition of corrosion are covered. Operational methods and conditions which could lead to corrosion can be recognized and eliminated by the present invention. Maintenance is also simplified since only then corrosion-protective measures (for example, dosage of high amounts of iron sulphate) are to be taken when it is necessary.

The present invention thus permits operation of heat exchangers (for example, condensers) more safely whereby the availability of thermal power plants is increased.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood from the following detailed description when considered in connection with the accompanying drawings, wherein like reference characters designate like or corrsponding parts throughout the several views, and wherein:

FIGURE 1 is a lateral view of two monitoring devices according to the invention for potential measuring, connected to a schematically illustrated heat exchanger;

FIGURE 2 shows a top view on the arrangement according to FIGURE 1;

FIGURE 3 is a detailed representation of a special design according to FIGURES 1 and 2;

FIGURE 4 is a detailed representation of an additional special design according to FIGURES 1 and 2;

FIGURE 5 shows a potential measuring system with a quicksilver/calomel reference electrode;

FIGURE 6 illustrates a copper/copper sulphate reference electrode of the present invention;

FIGURE 7 discloses a monitoring device according to the invention with a resistance measuring method; and

FIGURE 8 shows a monitoring device according to the invention with a polarization resistance measuring method.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The heat exchanger shown in FIGURES 1 and 2 includes, besides its heat exchanging portion with the tubes 2 to be monitored, an inlet water chamber 24 and an outlet water chamber 25. The corroding medium 3, i.e. the cooling water, enters and leaves the unit according to the arrows. The inlet water chamber 24 is connected with the outlet water chamber 25 by means of a large number of heat exchanger tubes 2 (only one of which is shown here in a dotted line).

The water chambers 24 and 25 are connected by one or several branches running outside the heat exchanger parallel to the heat exchanger tubes 2. The cooling water flows in these branches with the same speed as in the heat exchanger tubes 2. In FIGURES 1 and 2, two such branches are shown because, in the case of the lower branch, the branch-off point at the water chamber 24 is provided with a screen to retain cleaning shot. In this manner, the influence of the tube cleaning on the corrosive behavior can be determined.

The branches consist of a test tube 1 at both ends of which insulating piping 8, possibly of soft PVC, is installed which is fastened to the water chambers 24 and 25 through sockets. The inner diameter of the insulating piping 8 and of the test tube 1 is equal to or slightly larger than that of the heat exchanger tubes 2. At both ends of the test tube 1, a stop cock 23 is installed. A T-shaped insulating hollow body 9 is placed on the test tube 1 for the purpose of holding a reference electrode 4.

The device shown is based on the fact that a relatively short piece of tube, i.e. the test tube 1, through which the same cooling water flows with the same speed and which consists of the same material as the heat exchanger tubes 2 to be measured, reaches the free corrosion potential of the heat exchanger tubes 2 in the interior of the heat exchanger. With the design of the branch shown in FIGURES 1 and 2, no interfering inlet turbulence and no potential-shifting effect of possible protective anodes can occur.

As is shown in FIGURES 3 and 4, the test tube 1 has, for the purpose of monitoring the electrical potential it will reach, a small borehole 7 into which reference electrode 4 is placed which, in its turn, is held by a T-shaped hollow body 9 placed on the test tube 1 in FIGURES 1 to 3. The test tube 1 is provided with an electrical contact 5 and the free corrosion potential can be measured between test tube 1 and reference electrode 4 with

a suitable electrical millivoltmeter 6 with an inner resistance of at least 10^6 to 10^8 ohms. If this potential exceeds a certain value (i.e. the "localized corrosion potential"), the danger exists that corrosion occurs in a localized area. The entire branch with the test tube 1 rises in the flow direction so that the test tube 1 removes air on its own during operation and empties itself during a standstill mode. Since the pressure difference and the viscosity of the corroding medium 3 is a firmly given factor by the respective heat exchanger, the speed of the medium 3 is expediently adjusted by varying two dimensions(i.e. length and inner cross-section)of the test tube 1. However, since the cross-section should be such that the sponge shots of a cleaning system can pass therethrough, the necessity of a certain minimum length of the test tube 1 arises. In practice, the test tube 1 will be made of a piece of the used heat exchanger tubes 2 and its length should be at least approximately equal to one half of its diameter. However, as a rule, this length could amount to 5 - 200 times the diameter of the tube.

FIGURE 3 shows a test tube 1 through which the corroding medium 3, for example, cooling water, flows. The test tube 1 is connected with the heat exchanger by means of the insulating piping 8. Furthermore, a T-shaped tube is placed on the test tube 1 as an insulating hollow body 9 whose vertical portion 22 is exactly above the corresponding borehole 7 through the test tube 1. The insulating hollow body 9 is held on the test tube 1 by

means of two O-rings 12 and 14 and contact screw 10. Finally, the reference electrode 4 is connected, in an electrically conductive manner, with the electrical contact device 5 througn the millivoltmeter 6. Instead of making the contact through the electrical contact device 5, such can also be made through the contact screw 10 to the test tube.

In FIGURE 4, again a test tube 1 is shown through which the corroding medium 3 flows. In this design, a support tube 17 is slipped over the test tube 1. In this instance, a lateral recess 21 in the support tube 17 is above a borehole 7 of the test tube 1. The support tube 17 is held by means of two O-rings 12, 14 and a cover 18. A reference electrode 4 is inserted into the lateral recess 21.

The reference electrode 4 contacts the corroding medium 3 through the borehole 7 of the test tube 1. In order to be fastened, the reference electrode 4 is first pressed on an O-ring 13. Then, the reference electrode 4 can be fastened in a particularly safe and simple manner by means of an O-ring 13 and a screw tube 20 which, at the same time, makes it impossible for the reference electrode 4 to slip out during installation by means of a rotating plate 26 with retaining spring 19. The electrical supply line 27 runs to the reference electrode 4 through the rotating plate 26. The measuring instrument 6 (not shown) is connected, on the one hand, to the supply line 27 and, on the other hand to a contact device 5 on the test tube one, with the contact device 5 (not shown).

FIGURE 5 represents a potential measuring system with a quicksilver/calomel reference electrode which is immersed in the corroding medium 3 in which there is a metal sample 42. The reference electrode consists of an electrode unit 31 into which a narrow small tube 37 is sealed. The electrode unit 31 is also charged with a saturated KCl solution 29. The narrower small tube 37 is filled with quicksilver 30 and solid quicksilver-I-chloride ($Hg_2 Cl_2$ = calomel) 41 which is soluble with difficulty. This quicksilver 30 has, in comparison with the saturated KCl solution, a constant potential which is detected by the electrical supply line 36.

FIGURE 6 represents a copper/copper sulphate reference electrode as an additional example of a reference electrode 4. The electrode unit 31 has a charge opening 43 with a membrane 32 on the bottom and is charged with the saturated copper sulphate solution 33. A copper rod 34 is immersed in this solution which, in comparison with the copper sulphate solution, has a constant potential which is detected by the electrical supply line 36.

Although Figures 5 and 6 have shown a quicksilver/calomel reference electrode or a copper/copper sulphate electrode respectively, reference electrodes may also be of silver/silver chloride or silver/silver sulphate.

The invention under consideration is not only suitable for the monitoring of corrosion with the help of measuring the electrical potential whereby, as has already been explained, localized corrosion can be detected in time since the invention is actually also suitable for the monitoring of corrosion with the help of the resistance (i.e. so-called resistance method) and, additionally, for the monitoring of corrosion with the help of the polarization resistance (i.e. so-called polarization resistance measuring method).

FIGURE 7 shows a special design of the invention in accordance with the resistance measuring method. The test tube 1,which could be considered as being connected to a heat exchanger (not shown here) by means of the insulating piping 8, is arranged to let the corroding medium 3 flow through it. The test tube 1 also has two contact lugs 5', 5" as contact devices which are attached advantageously on both its ends. An electric resistance meter (ohmeter) 6 is provided as an electrical measuring instrument whose connections are attached to the contact lug 5", 5" through supply lines 27. The resistance measuring method is based on the recognition of the corrosion-caused reduction in the cross-sections of the tube 2 to be monitored. If, for example, metal removal, caused by corrosion, takes place, the electrical resistance of the test tube 1 increases and thus represents a measurable dimension for the progress of the corrosion.

In FIGURE 8, a special design of the invention for the monitoring of corrosion with the help of measuring the polarization is disclosed. As is shown in FIGURE 8, this design requires at least two individual test tubes 1', 1" which are connected with each other by an insulation line 8', possibly a piece of a PVC hose. The corroding medium 3 flows through the two test tubes 1', 1". The tube composed of two test tubes 1', 1" is to be considered as being connected to a heat exchanger, (not shown here) by means of additional insulating piping 8. The individual test tubes 1', 1"

have a contact lug 5', 5", respectively, as a contact device which is connected with the polarization resistance measuring instrument 6 as the electrical measuring instrument through the electrical supply line 27. Such a measuring instrument 6 is, for example, available from the company of Armin Lüdi, Bellevuestr. 112, 3028 Spiegel-Bern, under the trade mark Winking. The polarization resistance measuring is based on detecting the transfer resistance between metal and electrolyte which determines the corrosion speed.

The current which is expediently produced by a current source installed in the resistance meter (ohmeter) leaves, for example, the left test tube and enters again into the right test tube through the corroding medium. This discharge and admission work to be handled by the electrons with the discharge metal/corroding medium and with the admission corroding medium/metal is dependent on the surface property of the metal surface, such as for example, a corrosion-caused covering layer or corrosion-caused decomposition. The more difficult the work is which the electrons must handle, the higher then also is the electric resistance of these electric circuits which can be practically measured.

It goes without saying that, in a single branch, if so desired, all three types of measuring devices shown in this application or a combination of these three types can be applied by simply placing the individual devices one behind the other in a single branch and connecting them in series.

Finally, the particularly simple design of the invention should be pointed out which results in a very low price despite the great and surprising effectiveness of the invention. The special design with potential measuring permits demonstration of (also in case of metals being covered with a relatively dense covering layer) localized corrosion occuring under the covering layer. Of particular advantage is, in the case of all three designs, the possibility of continuous monitoring also during operation of the heat exchanger. The detection is thus effected at a time when the damage is still easily avoidable. Besides the possibility of a connection in parallel, several measurements can also be performed by connecting several test tubes in series in a single branch. The test tubes can be easily installed and removed, even during operation of the heat exchanger.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

CLAIMS:

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus for the monitoring of corrosion in at least one metal heat exchanger tube through which a corroding medium flows with an electrical measuring instrument controlled by the condition of a surface in contact with the corroding medium, which surface comprises the material of at least one tube to be monitored, said apparatus comprising: at least one branch placed parallel to the flow in said at least one tube to be monitored wherein said branch comprises a monitor tube connected via electrical insulating conduit means at its opposite ends to the heat exchanger tube to be monitored, and said monitor tube has an inner cross-section which is at least equal to that of said at least one tube to be monitored such that the corroding medium in the monitor tube flows with the same speed as in said at least one tube to be monitored, said monitor tube comprising the same metallic material as said at least one tube to be monitored; a reference electrode disposed in electrical contact with the corroding medium in said branch; an electrical contact device mounted on said monitor tube and said electrical measuring instrument being electrically connected with said reference electrode and with said contact device.

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2. An apparatus according to Claim 1, wherein the length and said inner cross-section of the monitor tube are dimensioned such that the speed of the corroding medium flowing in said monitor tube is equal to that in the at least one metal tube to be monitored.

3. An apparatus according to Claims 1 or 2, wherein said branch slopes upwardly in the direction of flow of the corroding medium.

4. An apparatus according to Claims 1 or 2 wherein said at least one tube to be monitored comprises a heat exchanger tube and said electrical measuring instrument comprises a millivoltmeter with an internal resistance of at least 106 to 108 ohms.

5. An apparatus according to Claims 1 or 2 wherein the length of the monitor tube is at least approximately equal to half the diameter thereof.

6. An apparatus according to Claims 1 or 2 wherein said monitor tube includes a borehole provided on the outer surface thereof, said electrical contact device comprising a contact lug, an electrically insulating hollow body surrounding said

lug and a holding device disposed at said borehole for receiving said reference electrode.

7. An apparatus according to Claims 1 or 2 wherein said monitor tube includes a borehole provided on the surface thereof, said electrical contact device comprising a contact lug, an electrically insulating hollow body surrounding said lug and a holding device disposed at said borehole for receiving said reference electrode, and said hollow body is in the shape of a T wherein a horizontal portion thereof surrounds the monitor tube and a vertical portion thereof forms said holding device for receiving said reference electrode.

8. An apparatus according to Claims 1 or 2 wherein said monitor tube includes a borehole provided on the surface thereof, said electrical contact device comprising a contact lug, an electrically insulating hollow body surrounding said lug and a holding device disposed at said borehole for receiving said reference electrode, and said hollow body comprises a supporting tube surrounding said monitor tube, a cover closing said supporting tube at one end thereof and through which the monitor tube passes, a squeezable element disposed between said cover, said outer surface of the monitor tube and said supporting tube wherein said supporting tube includes a recess formed therein standing vertically on the monitor tube for holding said reference electrode.

9. An apparatus according to Claims 1 or 2 wherein said reference electrode is selected from the group consisting of silver/silver chloride, quicksilver/calomel, silver/silver sulphate or copper/copper sulphate.

10. An apparatus for the monitoring of corrosion in at least one metal heat exchanger tube through which a corroding medium flows with an electrical measuring instrument controlled by the condition of a surface in contact with the corroding medium, which surface comprises the material of the at least one tube to be monitored, said apparatus comprising:

16 a branch placed parallel to the flow in the at least one tube to be monitored wherein said branch comprises at least one monitor tube connected via electrical insulating conduit means at its opposite ends to the heat exchanger tube to be monitored, and said at least one monitor tube has an inner cross-section which is at least equal to that of said at least one tube to be monitored such that the corroding medium in said at least one monitor tube flows with the same speed as in said at least one tube to be monitored, said at least one monitor tube comprising the same metallic material as said at least one tube to be monitored; and a pair of electrical contact devices mounted on said at least one monitor tube, said electrical measuring instrument being connected with said at least one monitor tube so as to form a closed electrical circuit.

11. An apparatus for the monitoring of corrosion in at least one metal heat exchanger tube through which a corroding medium flows with an electrical

measuring instrument controlled by the condition of a surface in contact with the corroding medium, which surface comprises the material of the at least one tube to be monitored, said apparatus comprising: at least two monitor tubes; an insulating line connecting said monitor tubes;

17 a branch placed parallel to the flow in said at least one heat exchanger tube to be monitored, wherein said monitor tubes each comprise a portion of said branch and said branch has an inner cross-section which is at least equal to that of said at least one tube to be monitored and the corroding medium in said monitor tubes flows with the same speed as in the at least one tube to be monitored, the monitor tubes comprising the same metallic material as the at least one tube to be monitored; and an electrical contact device connected to each of said monitor tubes, said electrical measuring instrument being electrically connected to form one electrical circuit with the monitor tubes through the contact devices, which electrical circuit is closed by the corroding medium.

12. An apparatus according to Claims 1, 10, or 11, further comprising two branches and a monitor tube comprising a part of each one thereof and a filter disposed upstream of one of said tube branches.

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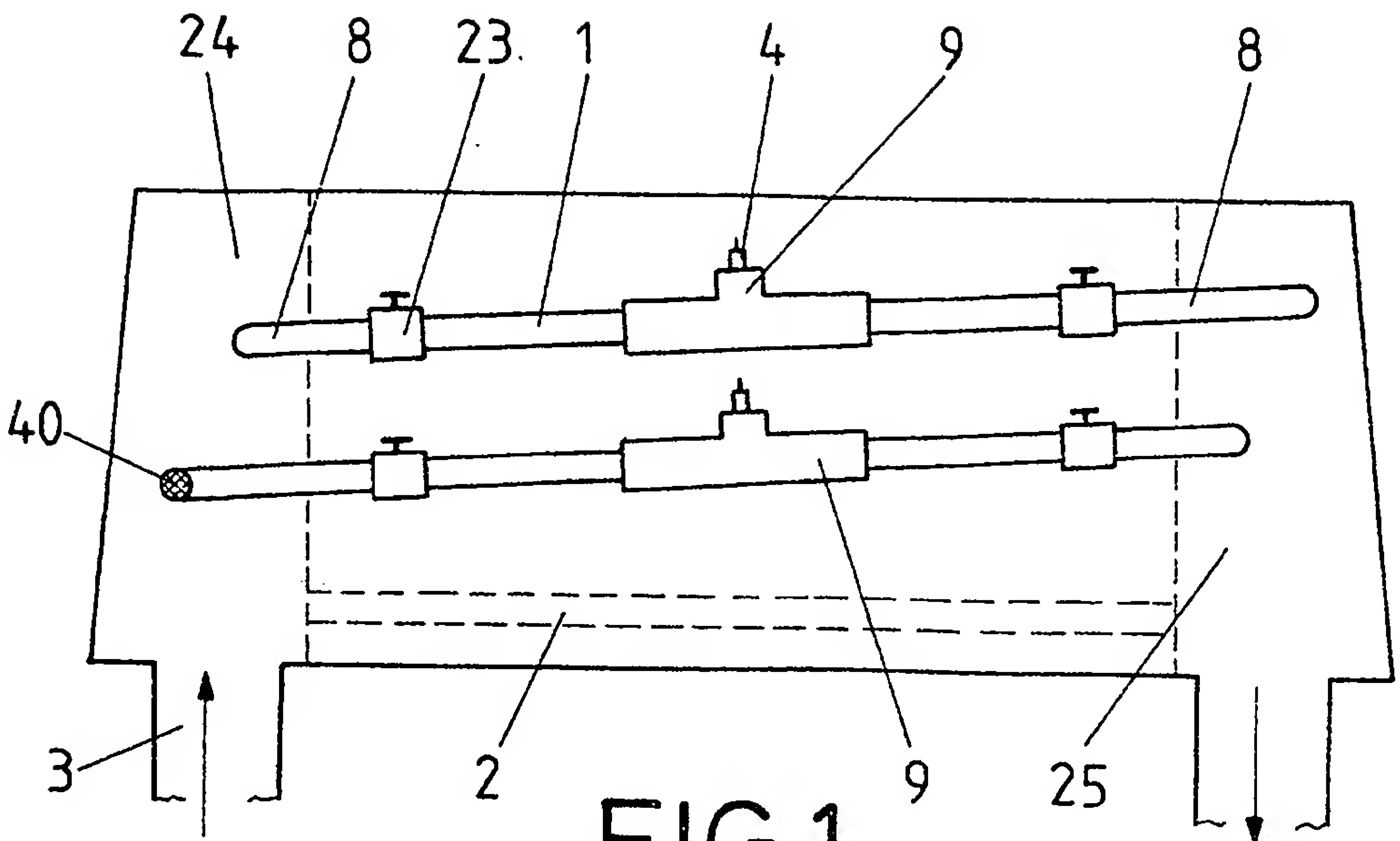

FIG.1

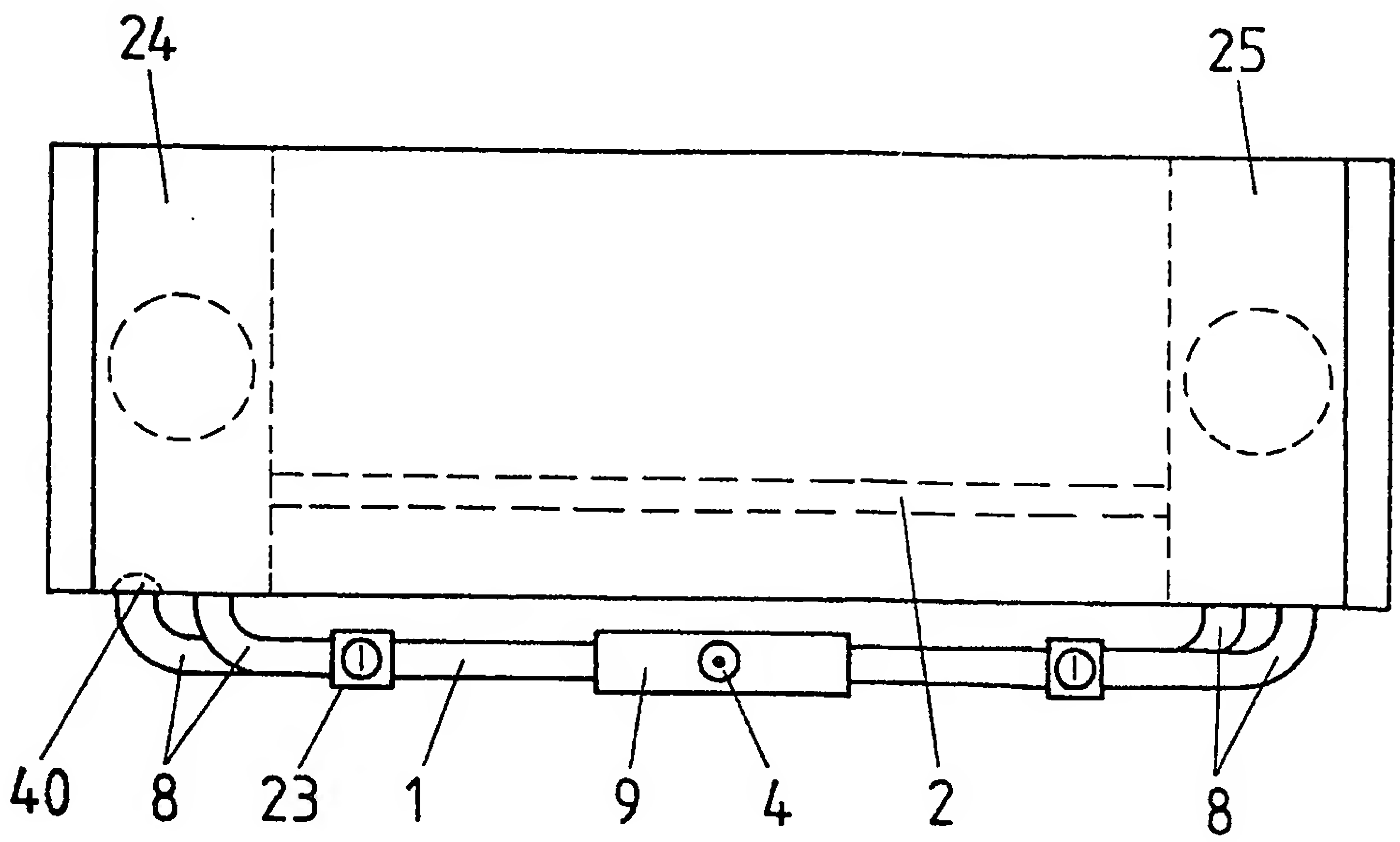

FIG.2

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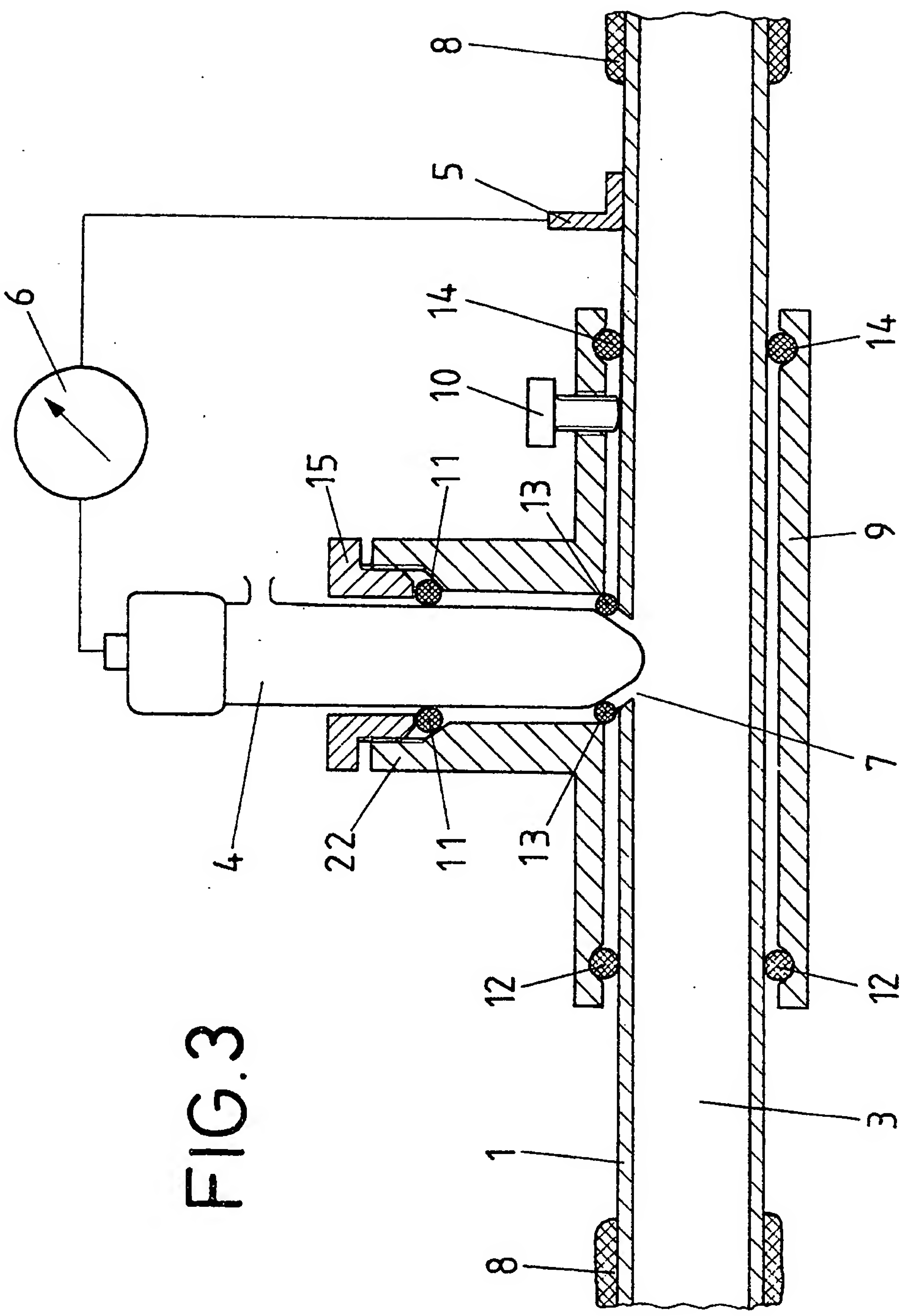

FIG.3

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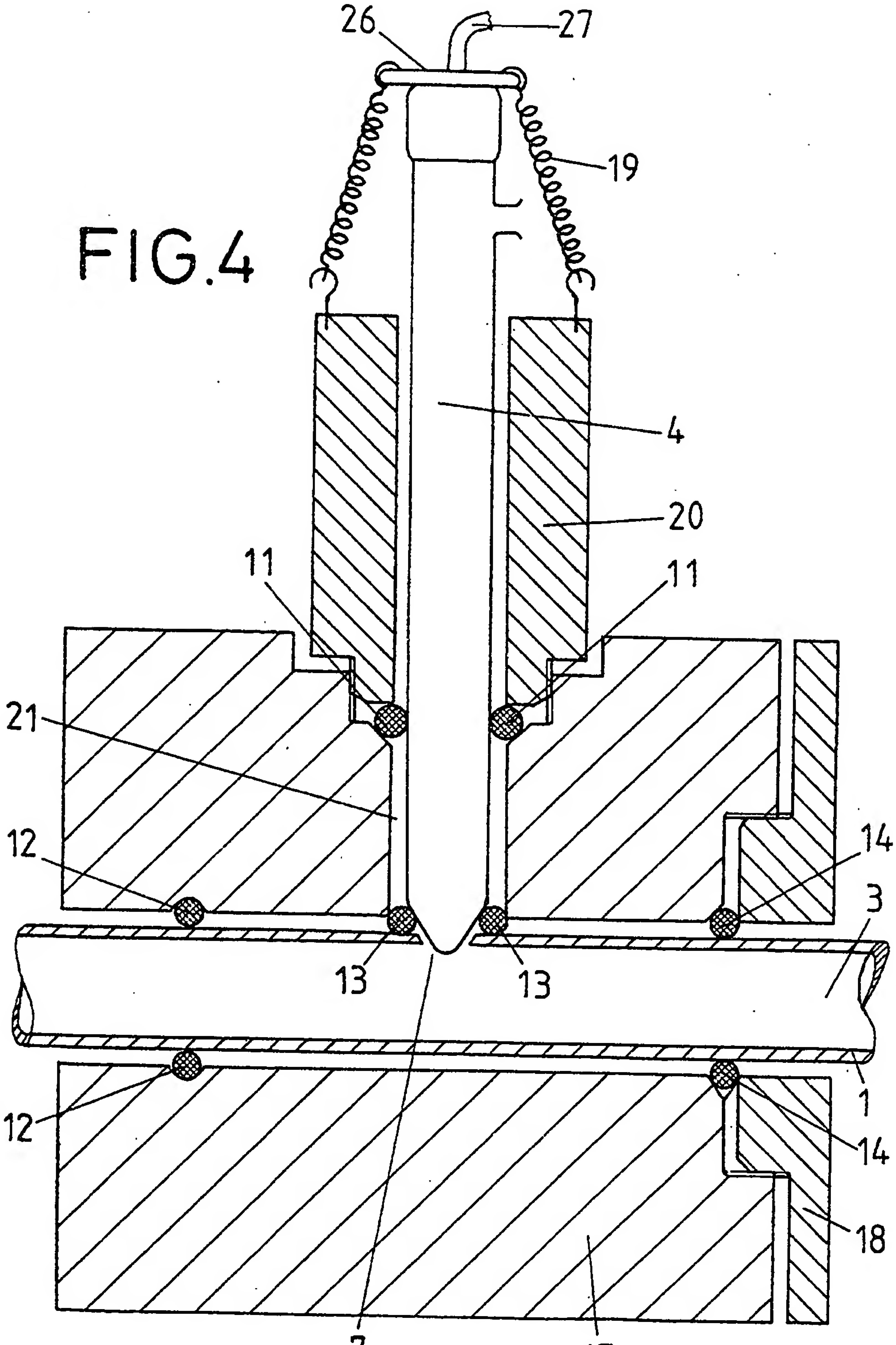
FIG.4



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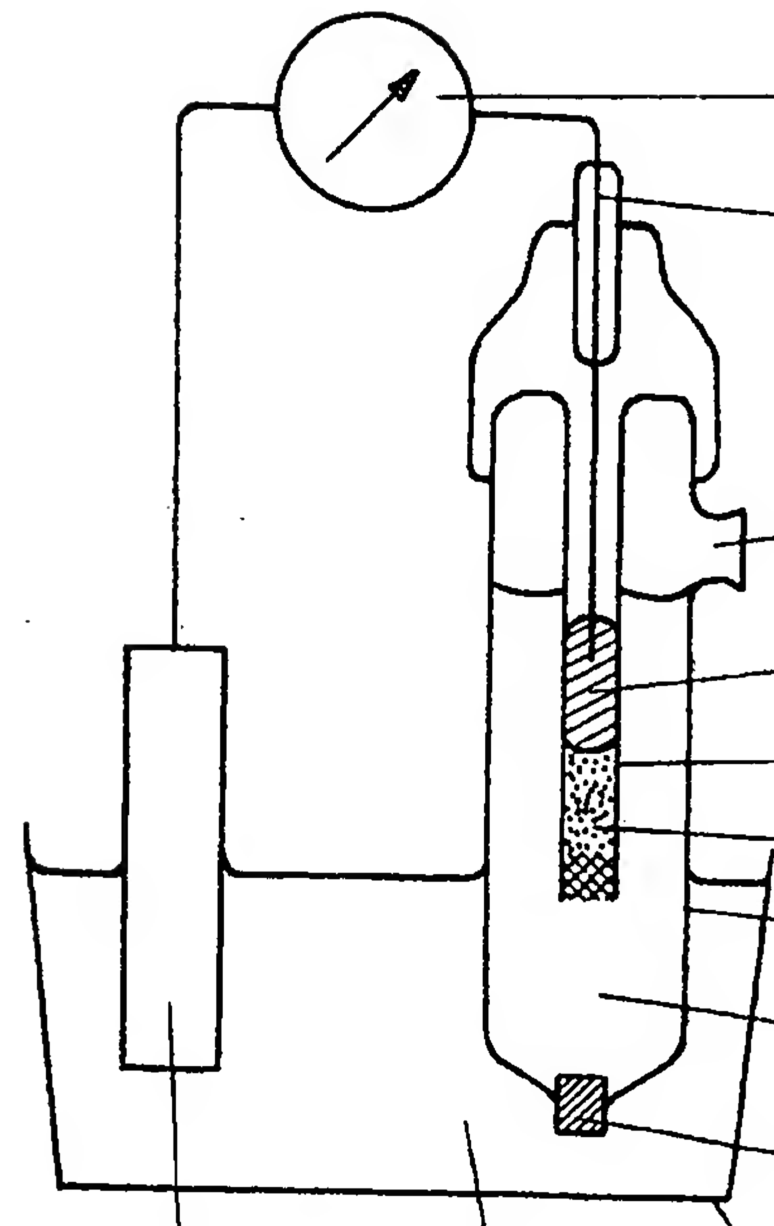

FIG.5

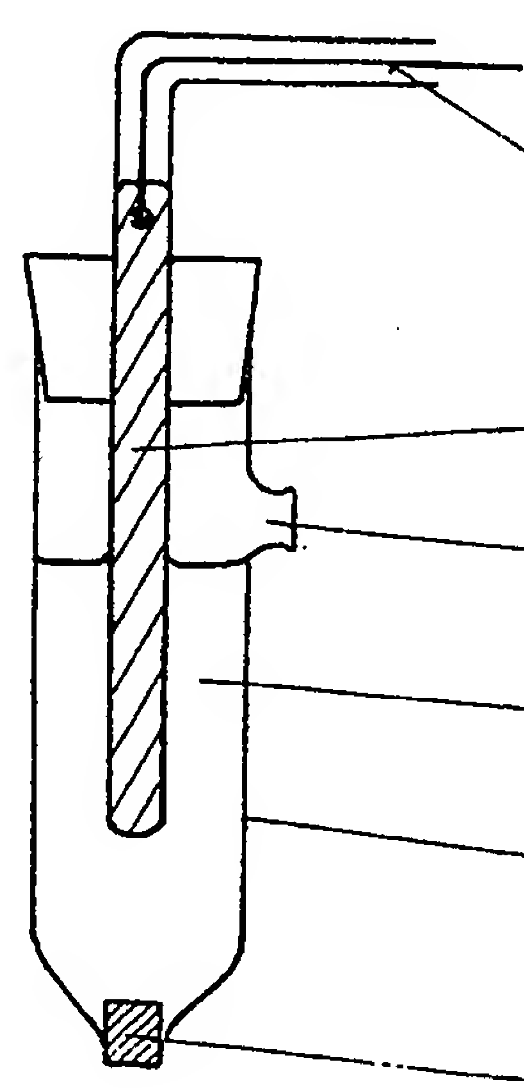

FIG.6

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FIG.7

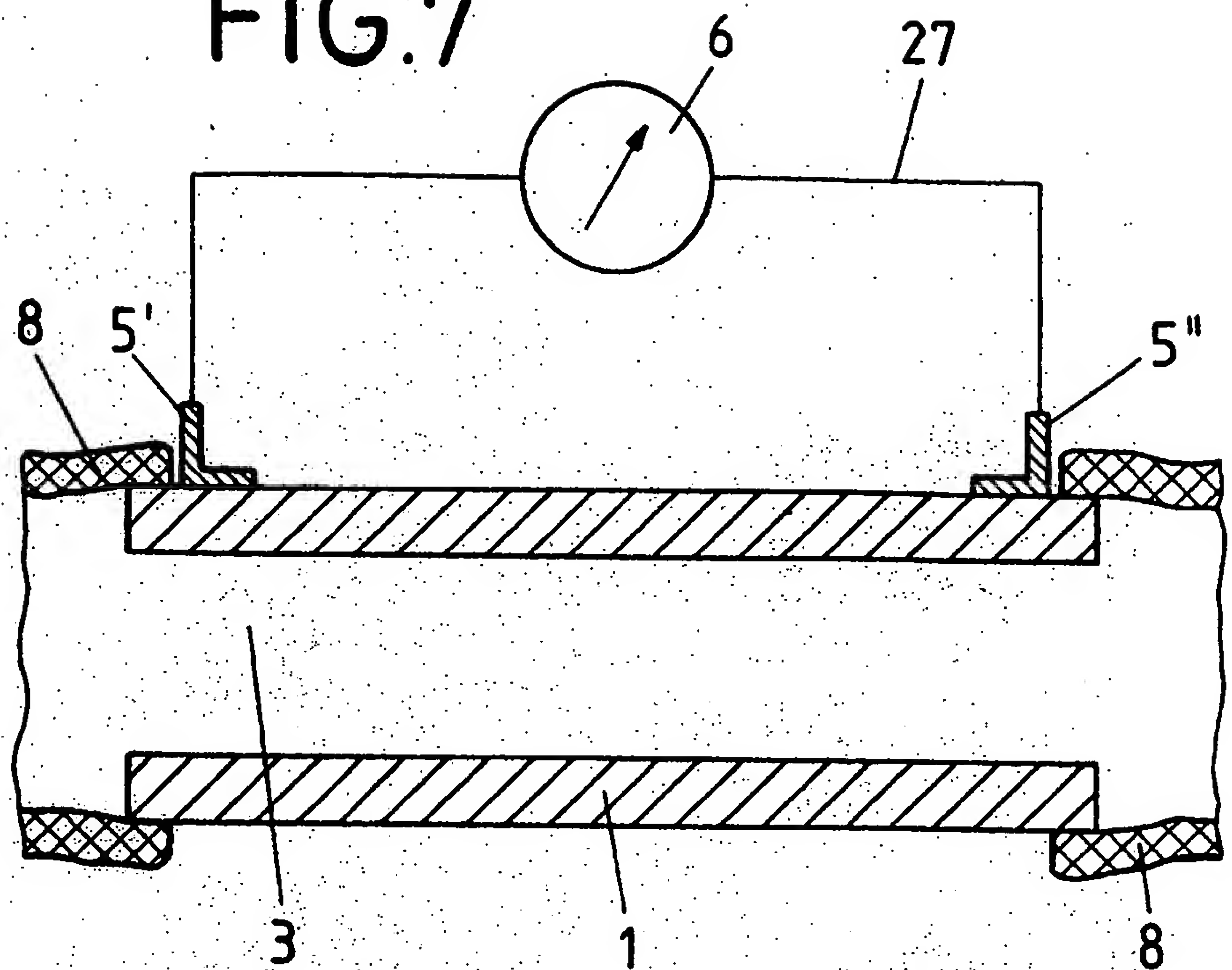
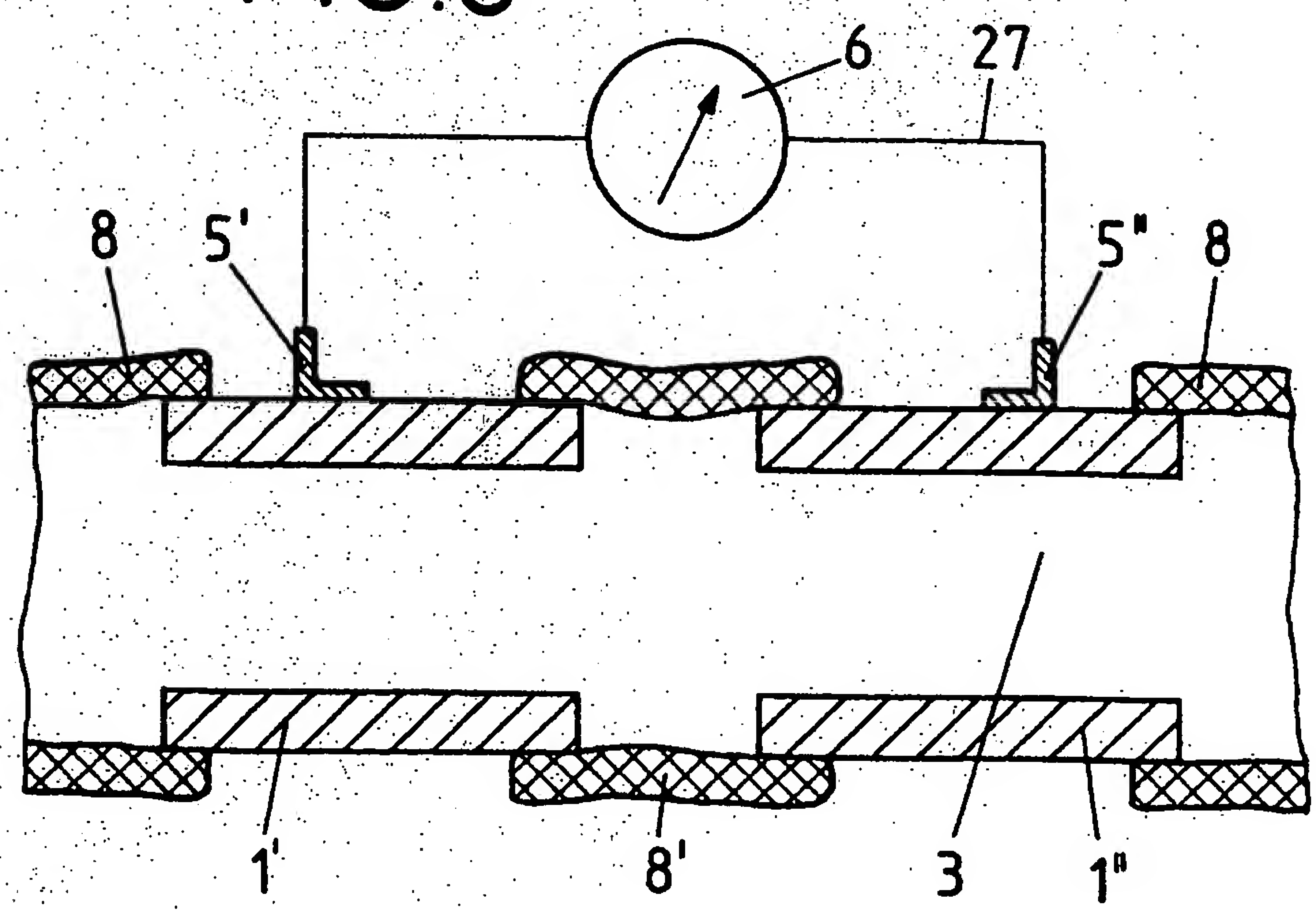


FIG.8



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